Research Article

Our experience of the Free Functioning Gracilis Muscle Transfer for Elbow Flexion in Brachial Plexus Injuries

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Abstract

Background: Brachial plexus injuries(BPI) are common in both blunt and penetrating trauma and can result in severe functional upper extremity deficits. Surgical reconstruction of these injuries is complex and often follows a stepladder pattern. Shoulder abductor and elbow flexor re-innervation involves both nerve repair and transfer techniques, which usually give reliable results only with early intervention. If the patients present late, however, or if there is no nerve to transfer or repair (as seen in root avusions), the only remaining option is transfer of a free functioning muscle neurotized by extra-plexal motor nerves to restore function. Freegracilis muscle transfer provides consistent elbow function in such cases, or in situations where previous nerve grafting and/or nerve transfer have produced disappointing results. The objective of this study is to share our experience of the free functioning gracilis muscle transfer in restoring elbow flexion.

Methodology: This retrospective study was done over a period of 4 years, by reviewing the records of all patients who underwent free functioning gracilis muscle transfer for restoration of elbow flexion in long-standing brachial plexus injuries. Functional outcomes were assessed clinically through MRC grading system and active range of motion (AROM) at the elbow joint was measured with goniometer. Patients were assessed at the 12 months of follow-up.

Result: Total number of patients with successful FFMTs were 21. According to MRC grading system 16 out of 21 (76%) patients were able to achieve power of M3 and above. AROM was <45° in 5 patients, 45° - 90° in 10 patients, and >90° in 6 patients. One patient was able to lift 2 kg weight as well.

Conclusion: Gracilis FFMT is a reliable procedure to restore elbow flexion in patients with brachial plexus injury in which there has been a delay in surgical intervention.

Received | 00-00-0000: **Accepted** | 00-00-0000
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Keywords | _____

Introduction

Brachial plexus injuriescause functional impairments of the upper extremity that range from mild weakness to total paralysis.[1,2] Recent advances in the field of microsurgery have provided valuable developments in reconstructive optionsafter brachial plexus injury.[3,4,5] Re-innervation of the biceps and shoulder musculature, by either nerve repair or nerve transfer techniques, brings about effective restoration of flexion of the elbow and abduction of the shoulder when performed early (3 to 6 months after trauma).[6,7,8] If the patient presents more than 6 months after injury, nerve transfer techniques can still achieve satisfactory results. In partial injuries donor nerves may be from within the plexus, whereas in pan-plexus injuries, nerves outside the plexus must be used as donor nerves.[10]

With further delays in presentation, exceeding 9-12 months after injury, attempts at restoring function by nerve repair or transfer are generally unsuccessful. Also, in cases of complete root avulsions, reconstructive options are limited, and multiple functions need to be restored. This has led to the use of free functioning muscle transfers (FFMTs) combined with extra-plexal motor nerves to re-establish function in such situations.[11,12] Free functioning muscle transfer can produce satisfactory elbow flexion in such cases and following unsuccessful nerve procedures, or in cases unsuitable for tendon transfers.[13] Doi, et al[11,13] described a procedure involving two FFMTs, one for elbow flexion and finger extension and the otherfor finger flexion. This provides a means of restoring basic hand function in delayed pan plexus injuries.[14]

With meticulous technique and consistent follow-up with regular physiotherapy, FFMT provides restoration of adequate elbow flexion. In this study, we describe the functional results of gracilis FFMTs for restoration of elbow flexion after brachial plexus injuries at our institute.

Methodology

This was a retrospective study done at Liaqat national hospital over a 4-year period from march 2015 till Feb 2019. The records of all patient with brachial plexus injuries who underwent free functional muscle transfer (FFMT) of the gracilis muscle were reviewed. Patients of all ages and due to any cause of brachial plexus injury were included in the study. Patients whose follow-up was less than 12 months and those who required an ancillary procedure to reinforce elbow flexion were not included in this study.

Functional outcome was assessed after completing 12 months of follow-up, on two parameters: power of elbow flexion and active range of motion at elbow. The Medical Research Council (MRC) grading system was used for evaluation of the power of elbow flexion and categorized as excellent (Grade M5), good (Grade M4), fair (Grade M3), and poor (Grade <M2).Active range of motion (AROM) at the elbow joint, measured with a goniometer, was categorized as excellent (>90º and able to lift 2 kg weight), good (>90º without weight), fair (45º - 90º), and poor (<45º).

Surgical technique:

A two team approach was used, where one team harvested the gracilis muscle flap from the contralateral thigh and the second team prepared the recipient site. The gracilis muscle was marked at 5cm intervals with methylene blue while in situ. It was then harvested with its dominant vascular pedicle (ascending branch of the medial circumflex femoral artery and its accompanying venae comitantes,) and its nerve, the anterior branch of the obturator nerve. The muscle flap was insetat the recipient site and its length and tension adjusted by using the 5cm interval marks as guides. During inset the elbow was positioned in 45° of flexion, the forearm was positioned in supination, and the wrist, metacarpophalangeal joints (MCPJs) and interphalangeal joints (IPJs) were kept in a neutral position. The gracilis muscle was then attached proximally to the second rib or the acromion process, tunneled through the flexor compartment of the upper arm, passed under the brachioradialis muscle and sutured distally to the extensor digitorum communis (EDC) and extensor pollicis longus (EPL) tendons. The nerve to gracilis was coapted to the intercostal nerves and the vascular pedicle was anastomosed to the thoracoacromial artery and vein.

Fig. 1. *Gracilis Muscle Marked In-situ at 5cm Interval*

Results

From January 2015 to December 2019, we performed free functioning gracilis muscle transfer to restore elbow flexion in 26 male patients with post-traumaticbrachial plexus injuries. The mean age was 27.5 years (range 18-37) and the mean duration since injury was 42 months (range 14-153). The dominant limb was involved in 15 cases. The mechanisms of injury were road traffic accidents (RTA) in 19 and firearm injuries (FAI) in 7 cases.

5 out of 26 flaps (19%) failed due to vascular compromise. Out of the 21successfulgracilis FFMT, 2 patients did not achieve any flexion at the elbow joint, and were

graded as M0, one had power of M1 with mild flickering, two patients achieved power M2. Ten patients were able to achieve elbow flexion against gravity and were graded as M3. Finally, good restoration of elbow flexion was seen in 6 patients with power equivalent to M4. None of the patients achieved gradeM5 (Figure 1).

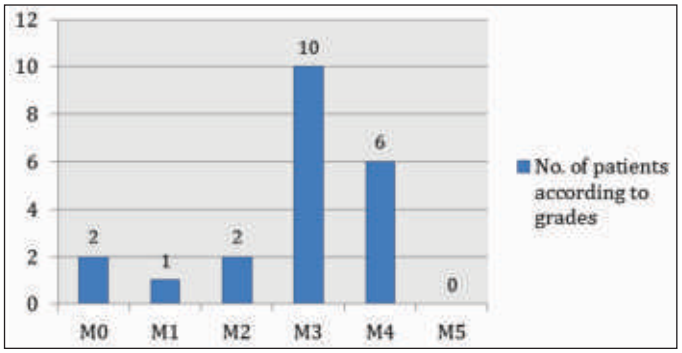

Figure 1: Patient Distribution according to MRC Grade Achieved

AROM with elbow flexion of <45°was seen in 5 patients, and in 10 patients it was noted to be 45°-90°. 5 patients were able to achieve elbow flexion with AROM >90°, but were unable to lift a 2 Kg weight, and 1 patient was able to flex his elbow with AROM >90°and was able lift a 2 Kg weight (figure 2).

There were minimal donor site complications. One patient developed a seromaat the donor site. None of the patients developed pneumothorax during intercostal nerve harvesting.

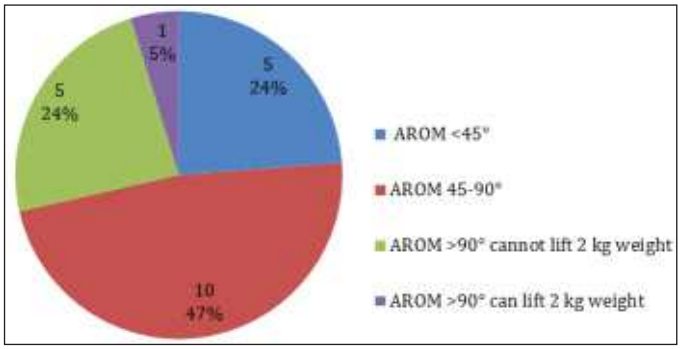

Figure 2: *Distribution of Patients according to AROMAchieved*

Discussion

Traumatic brachial plexus injuries can cause debilitating loss of upper limb function. Restoration of function in such cases requires complex surgical reconstruction. With modern surgical techniques, flexion at the elbow and stability of the shoulder can be significantly restored, if prompt surgical intervention is done[15,16]. In patients with lower plexus root avulsion injuries, nerve transfers and tendon transfers can restore basic functions of hand such as grasping. In long-standing pan-plexus injuries, however, micro-vascular free tissue transfer to the affected arm is the mainstay of the reconstructive surgical plan. Successful results depend not just on the nature of the plexus injury (site, mechanism, and time since injury) and associated trauma, but alsoon surgical skills, operative time limitations, and postoperative rehabilitation.

Brachial plexus injuries can be differentiated into preganglionic injuries that involve avulsion of roots, and postganglionic injuries that are distal to the dorsal root ganglia. This distinction is essential for planning the appropriate reconstructive procedure. Postganglionic lesions can be managed by nerve repair and by neurotization or nerve transfer techniques from donor nerves available in the plexus or outside the plexus.[17,18] Injuries of the brachial plexus in which the nerve roots are avulsed (preganglionic lesions) are practically impossible to repair. Neurotization of important muscles from the nerves outside the plexus or FFMTs are the only available options.[7] When surgical intervention is carried out early, neurotization of the biceps muscle directly by the intercostal nerves can restore elbow flexion. Gracilis FFMT is recommended when there is avulsion of nerve roots, and the treatment is delayed by more than 9 to 12 months[13].

One of the major difficulties in rehabilitation of brachial plexus injuries is the limited availability of donor motor nerves for neurotization. Commonly used donor nerves to reestablish upper extremity function are the intercostal nerves and spinal accessory nerves, but no consensus currently exists as to which motor nerves are the best donors.[19,20] Restoration of function in patients who present with a flaillimb is challenging. Prolonged denervation causes fibrosis and atrophy of the muscles, and direct neurotization is not possible. The only option available to restore function is FFMT with extraplexal neurotization. The main advantage of FFMT is that it provides prehensile function. Doi et all[13] and others have demonstrated successful restoration of prehension by performing FFMT only, and simultaneous restoration of two functions by one free muscle transfer. Neurotization of the gracilis muscle attached to clavicle by the second and third intercostal nerves can produce elbow flexion and finger or wrist extension while the second transfer, attached to the second or third rib and neurotized by the fourth and fifth intercostal motor nerves, produces finger flexion. Additionally, intercostal nerves can be used for triceps function and sensory innervation of the hand, producing independent flexion and extension of the elbow and function of the hand. The expectations of the patients about functional outcome should be realistic, and they should be counseled regarding extensive

post-operative rehabilitation before undergoing surgery. Patients may opt for a single procedure that produces elbow flexion, instead of two-staged procedures such as the double FFMT.

In this study, we performed gracilis FFMTs to achieve elbow flexion in brachial plexus injury patients in whom the time from injury to surgical intervention was more than 12 months and in patients who opted for restoration of the prehensile function of hand. Our experience provides additional support for the use of gracilis FFMTs as an option for reconstruction in above-mentioned scenarios.

Conclusion

Gracilis FFMT can reliably restore the elbow flexion in patients with delayed presentation of brachial plexus injuries, with an acceptable muscle power grade and active range of motion at the elbow joint.

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